956,191

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Wellhead Assemblies

We, SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ N.V., a Company organised under the Laws of the Netherlands, of 30 Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a wellhead assembly adapted to be secured to the top of a well casinghead of an oil or gas well for controlling the fluid flow from the well. The invention provides a wellhead assembly which can be entered vertically for workover operations, while at the same time a side entry is provided so that various, tools, instruments and other devices can be circulated into the well. The invention also extends to closure means of simple design and positive action adapted to be positioned and locked in a vertical conduit of the wellhead assembly.

A recent development in the drilling and completion of oil and gas wells has been the drilling and completion of underwater wells wherein the wellhead assembly and the casinghead may be both positioned hundreds of feet below the surface of the water at an offshore location. Methods for carrying out maintenance and other operations on a well the wellhead assembly of which is positioned a considerable distance below the surface of the water have been developed. One of these methods has been termed a "through-the-flowline" well maintenance technique. For performing the operations involved in maintaining the wells in this manner, certain tools and other devices which are capable of being pumped into and out of the wellbore through the production flowline have been developed. Since these maintenance tools must be pumped into the wellbore, and since they are not able to pass around the right-angle bend in a normal wellhead assembly, new types of wellhead fittings are required to carry out such operations.

One form of a wellhead assembly particularly adapted for this purpose is described in British specification No. 924,903. That patent application describes a wellhead assembly adapted to be secured to the top of a well casinghead for controlling the fluid flow from a well while providing dual-flow conduits which selectively permit the vertical entry of devices into the well as well as the circulation of devices into the well. The wellhead assembly includes a casinghead closure connected to the casing which includes a spool member having at least one vertical conduit therethrough in register with a tubing string within the well, and a smoothly-curved side conduit branching upwardly and outwardly from the side wall of the spool member and from the vertical conduit therein. A closure device is provided for closing the vertical conduit through the spool member when it is not in use.

It is an object of the present invention to provide a wellhead assembly including a conduit closure member of simple design and positive action which can be pumped through a flowline into the wellhead and positively locked therein, and removed therefrom as required, such operations being carried out from a remote location.

According to the present invention a wellhead assembly adapted to be secured to the top of a well casinghead includes a spool member having at least one vertical conduit therethrough adapted to register with a tubing string suspended in a well, a smoothly-curved side conduit branching upwardly and outwardly through the side wall of the spool member from the vertical conduit therein, a closure member for closing the vertical conduit removably positioned in the spool member, the bore of the vertical conduit being enlarged at one point forming a latching groove, outwardly-extensible latching means carried in a recessed portion of the closure member

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and adapted to be forced into the latching groove of the spool member by latch-actuating means comprising a cam surface carried by the closure member, a fishing neck formed on the top of the latch-actuating means for the closure member for removing the closure member from the spool member, the lower end surface of the closure member being shaped to form a continuation of the inner wall of the smoothly-curved side conduit, registering first and second guide means, one of the guide means being carried by the closure member and the other on the inner wall of the vertical conduit of the spool member whereby the engagement of the first guide means with the second guide means upon passage of the closure member in the vertical conduit of the spool member causes the closure member to rotate in the vertical conduit until the lower end surface thereof registers with the inner curving wall of the side conduit.

The invention may be performed in various ways and a specific embodiment, with alternative forms of closure member, will now be described by way of example with reference to the accompanying drawings, wherein:

Figure 1 is a schematic view illustrating an underwater wellhead assembly embodying the present invention;

Figures 2 and 3 are elevations, partly in section, of two forms of closure member adapted to fit within the vertical bore of the wellhead assembly; and

Figure 4 is a diagrammatic view of a retrieving tool for retrieving the closure members.

While the wellhead assembly of the present invention is described hereinbelow with regard to a well having two strings of production tubing suspended therein, it can be modified so as to be employed on wells having a single string of tubing therein, or on wells having two concentric strings, or on wells having three or more parallel strings of tubing suspended within the well.

Referring to Figure 1 of the drawings, a casinghead closure member 11 having an annular sealing element 12 on its outer surface is shown as positioned on the inner sloping seating surface 13 at the top of a casinghead 14, thus closing the casinghead 14 in a fluid-tight manner. The casinghead closure member 11 is provided with a pair of vertical conduits 15, 16 centrally disposed side-by-side and extending vertically down through the casinghead closure member 11 in register with a pair of strings of production tubing (not shown) suspended within the well. It is assumed that the well casinghead 14 and the wellhead assembly of the present invention are mounted on an offshore well and are positioned underwater.

Fixedly secured to the top of the casinghead closure member 11 by bolts 17 is a master valve 18 by which the well may be shut-in upon closing of the valve 18. The valve 18 is preferably of the remotely-controlled full-opening type, that is, each gate or plug controlling the flow within the valve is of a type that, when opened, furnishes a straight passageway through the valve of a diameter substantially equal to that of the respective vertical conduit 15 or 16. For this particular installation the master valve 18 would be the one having two flow passageways and two closure members therein, since it is arranged to close both of the vertical conduits 15 and 16.

Fixedly secured to the top of the master valve 18 is a spool member 21 having a pair of vertical conduits 22 and 23 therethrough in register, through the master valve 18, with the vertical conduits 15 and 16 in the casinghead closure member 11.

Smoothly curving from the vertical conduits 22 and 23 of the spool member 21 are a pair of side conduits 24 and 25 which branch upwardly and outwardly through the side wall of the spool member 21. The curvature of the side conduits 24 and 25 depends, to some extent, upon the length and flexibility of the tools, instruments or other devices to be circulated down into the well through the side conduits. Thus, with the presently-developed tools, the radius of curvature of the side conduits 24 and 25 may be about 5 feet.

Each of the side conduits 24 and 25 is provided with a flange 26 and 27, or other coupling means, connecting a pair of remotely-controlled valves 30 and 31 to the side conduits 24 and 25. A pair of production flowlines 32 and 33 are connected to the other sides of the control valves 30 and 31. The flowlines 32 and 33 lead from the top of the wellhead assembly, eventually curving outwardly and downwardly to the ocean floor and then run along the ocean floor to shore to some tank or installation positioned offshore or onshore for collection or separation purposes. If the sections of the production flowlines 32 and 33 directly connected to the flow valves 30 and 31 are rigid, they would be smoothly curved in an arc of a radius no less than that which would permit devices to be circulated therethrough into the well. Whether the flowlines 32 and 33 are of a rigid or flexible material, all curves therein must have a minimum radius at least equal to the minimum required for circulation of devices therethrough.

Tools, instruments and other devices can be readily circulated down through the production flowline 32, the side conduit 24 and thence through the vertical conduits 22 and 15 down into the well. However, on circulating a device (not shown) up from the bottom of the well, by reversing the circulation of fluids through the flowlines 32 and 33, the device would be driven up through the vertical conduit 15 and conduit 22 and become lodged in the vertical continuation of the latter rather

than sweeping out through the side conduit 24 and thence through the production flowline 32. It therefore has been found necessary to provide the vertical conduits 22 and 23 of the spool member 21 with diverting plugs or closure members 34 and 35 which are removably positioned therein to close the vertical continuations of the conduits 22 and 23 above the side conduits 24 and 25. The lower ends 36 and 37 of the closure members 34 and 35, respectively, are shaped in a manner such that the lower tapered face thereof forms a continuation of the inner wall of the smoothly curved side conduits 24 and 25. That is, the lower end 37 of the closure member 35 is curved in an arc of the same radius as the bend of the side conduit 25, being also machined, cut or otherwise formed to provide a concave transverse curvature of a radius equal to that of the bore of the conduit 25.

One form of closure member 35 is illustrated in Figure 2. A lower body portion 40 thereof having the curved lower end 37 is of a diameter substantially equal to the diameter of the vertical conduit 23 in which the body portion is positioned. Above the body portion 40 is a shank 41 of smaller diameter on which an upper body portion 47 is mounted carrying various latching, sealing and orientating elements. Certain portions of the vertical conduit 23 are enlarged in diameter, as at 42 in order to receive an orienting device, and at 43 to form a latching groove into which latching elements 44 can be received for latching the closure member in place within the spool member. In this embodiment the latching elements 44 are balls, but other latching elements such as tapered plugs or dogs may be used. Additionally, the wall of the conduit 23 is tapered at 45 to form a landing shoulder for receiving a seating surface 46 on the outer surface of the upper body portion 47.

Although the wellhead assembly of the present invention is generally provided with a control valve 56 which is flanged to the top of the spool member 21 (Figure 1) in order to close the vertical conduits therethrough in a fluid-tight manner, it may be desired to provide an additional seal 50 on the body member 47 of the closure member. If the seal 50 is employed, the bore of the conduit 22 is reduced at 51, so that the seal will seat against the inner wall of the conduit 23 in a fluid-tight manner without rubbing against the wall of the conduit and/or a tubing string at any other point. Extending into the enlargement 42 of the bore of the conduit 23 is a guide element 52 which is fixedly secured to the spool member in any suitable manner. Fixedly carried on the upper body portion 47, as in screw-threaded engagement at 53, is a series of collet fingers 54 having enlarged ends 55 each with a tapered face 57 adapted to engage a tapered face 58 at the upper end of the enlarged portion 42 of the conduit 23. The collet fingers 54 are spring-like elements which can be pressed inwardly towards the shank 41 when the closure member is being pumped into or withdrawn from the wellhead. For ease of illustration, only two of the collet fingers 54 and 54*a* are shown in Figure 2, the complete set of collet fingers being illustrated in Figure 1. The collet fingers vary in length so that their ends form a sloping surface adapted to guide the shortest collet finger 54*a* into an orientated position adjacent the guide element 52.

The apparatus for actuating the latching balls 44 comprises a sleeve 60 which is mounted for limited axial movement within the upper body portion 47 of the closure member. The sleeve 60 has a tapered cam surface 61 adapted to bear against the latching balls 44 and force them into the latching groove 43. The sleeve 60 above the tapered cam surface 61 has a blocking shoulder 62 which prevents the latching balls 44 from moving out of the latching groove 43. The axially-slidable sleeve 60 is acted upon by a spring 63 which normally pulls the sleeve 60 downwardly and urges the tapered cam surface 61 against the latching balls 44 to force them into their operative position within the latching groove 43. However, the spring 63 may be omitted if the sleeve 60 is heavy enough readily to force the latching balls 44 into their operative position.

To supplement the positive locking action supplied by the spring 63, the sleeve 60 may be provided with at least one spring-loaded locking dog 64 pivotally mounted on a pin 65 around which a spring (not shown) is wound. The pin 65 is preferably a shear pin. An internal shoulder 66 is formed at the upper end of the body portion 47 which is engaged by the locking dog 64. The locking dog 64 is positioned in a manner such that in its operative position, as illustrated in Figure 2, one end 67 of the locking dog extends into a bore 68 drilled down the centre of the sleeve 60 from the top thereof which includes a fishing neck 70. The closure member of Figure 2 can be removed from the wellhead assembly by a suitable retrieving or fishing tool such as is illustrated in Figure 4. The fishing tool of Figure 4 comprises a rod 71 of a diameter to fit within the bore 68 of the fishing neck 70, and of a length sufficient to engage the end 67 of the locking dog 64 and force the locking dog 64 into a retracted position, at the same time letting spring elements 72 on the fishing tool latch under the fishing neck 70. The fishing tool may be connected to the end of a wire line or may be connected by means of a swivel joint 73 to a suitable motor swab 74.

The diverter plug or closure member of Figure 3 is similar to that illustrated in Figure 2, the main difference being with regard to the guiding or orientating device which in this case comprises an orientating shoulder 79 formed on the inner wall of a sleeve 80 inserted

in the vertical conduit together with a single collet finger 81 having an enlarged end 82 adapted to seat in a groove at the bottom of the orientating shoulder 79. Instead of providing a sleeve 80, an orientating shoulder corresponding to 79 could be formed directly in the vertical conduit of the spool member.

The latching elements are of a size such that they will not latch in any groove encountered in the flowline or wellhead until they are positioned opposite the latching groove 43. In a like manner, the enlarged ends 55 or 82 of the collet fingers 54 or 81, respectively are of a length greater than the latching groove 43 so that they do not accidentally seat therein. In installing the diverter plugs or closure members 34, 35, they could be dropped, lowered or pumped down through a vertical tubing string from a point above the surface of the water, the lower end of the tubing string being in vertical register through conduits 75 and 76 (Figure 1) with the conduits 22 and 23. On arriving in the spool member 21, the collet fingers 54 (Figure 2) or 81 (Figure 3) of the closure members will engage the co-operating guide element 52 (Figure 2) or 79 (Figure 3) mounted in the spool member 21, whereby the further passage of the closure member in the vertical conduit means of the spool piece 21 causes rotation of the closure member therein until the lower end of the closure member is in register with the inner curving wall of the side conduit 24 or 25.

If the locking dogs 64 are corroded at the time it is desired to remove the diverting plug or closure member from the wellhead, a predetermined tension could be applied to the fishing neck 70 to shear the pins 65.

WHAT WE CLAIM IS:—

1. A wellhead assembly adapted to be secured to the top of a well casinghead, the assembly including a spool member having at least one vertical conduit therethrough adapted to register with a tubing string suspended in a well, a smoothly-curved side conduit branching upwardly and outwardly through the side wall of the spool member from the vertical conduit therein, a closure member for closing the vertical conduit removably positioned in the spool member, the bore of the vertical conduit being enlarged at one point forming a latching groove, outwardly-extensible latching means carried in a recessed portion of the closure member and adapted to be forced into the latching groove of the spool member by latch-actuating means comprising a cam surface carried by the closure member, a fishing neck formed on the top of the latch-actuating means of the closure member for removing the closure member from the spool member, the lower end surface of the closure member being shaped to form a continuation of the inner wall of the smoothly-curved side conduit, registering first and second guide means, one of the guide means being carried by the closure member and the other on the inner wall of the vertical conduit of the spool member whereby the engagement of the first guide means with the second guide means upon passage of the closure member in the vertical conduit of the spool member causes the closure member to rotate in the vertical conduit until the lower end surface thereof registers with the inner curving wall of the side conduit.

2. A wellhead assembly as claimed in Claim 1 including a blocking shoulder formed on the latch-actuating means for engaging the latching means in their extended position, the latch-actuating means being axially slidable on the closure member, and a spring carried by the closure member for normally urging the latch-actuating means against the latching means.

3. A wellhead assembly as claimed in Claim 1 or Claim 2 including locking dogs carried by the latch-actuating means and adapted to engage a locking shoulder on the closure member to prevent axial movement of the latch-actuating means relative to the closure member when the latching means are seated in the latching groove of the spool member.

4. A wellhead assembly as claimed in any one of the preceding claims wherein the bore of the vertical conduit is tapered at an axially-displaced point from the latching groove to form a landing shoulder and is reduced at another point to form a sealing surface, and the closure member carries a seal for making fluid-tight contact with the said sealing surface and also a seating shoulder for seating on a landing surface within the spool piece.

5. A wellhead assembly substantially as described with reference to Figures 1, 2 and 4 or Figures 1, 3 and 4 of the accompanying drawings.

6. A closure member forming part of a wellhead assembly as claimed in Claim 1 and substantially as described with reference to Figure 3 of the accompanying drawings.

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Agents for the Applicants.

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956191 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

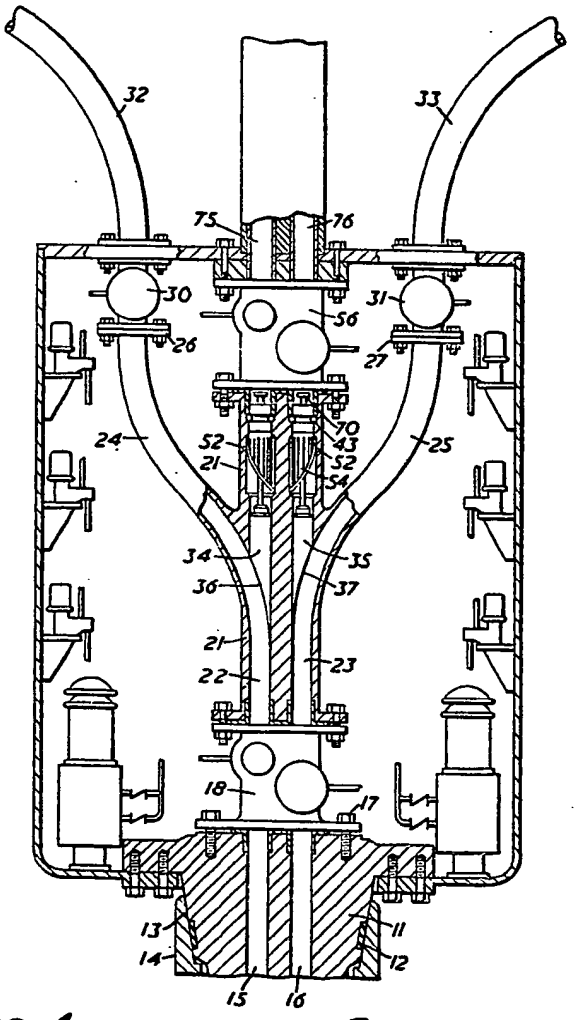

FIG. 1.

FIG. 4.

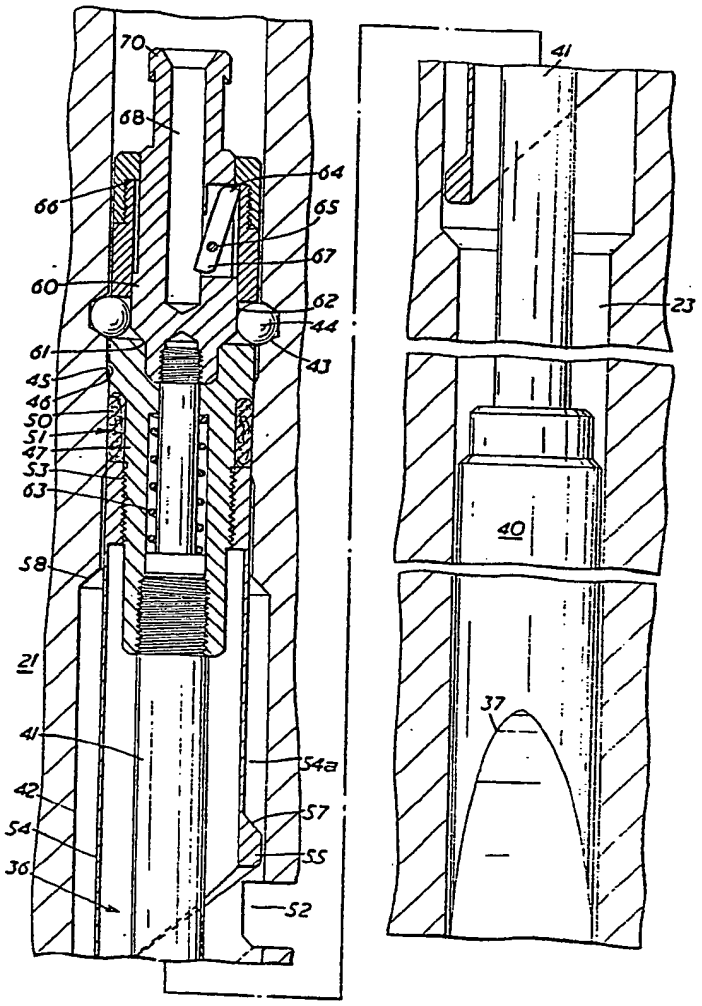
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FIG. 2.

956191 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 2 & 3

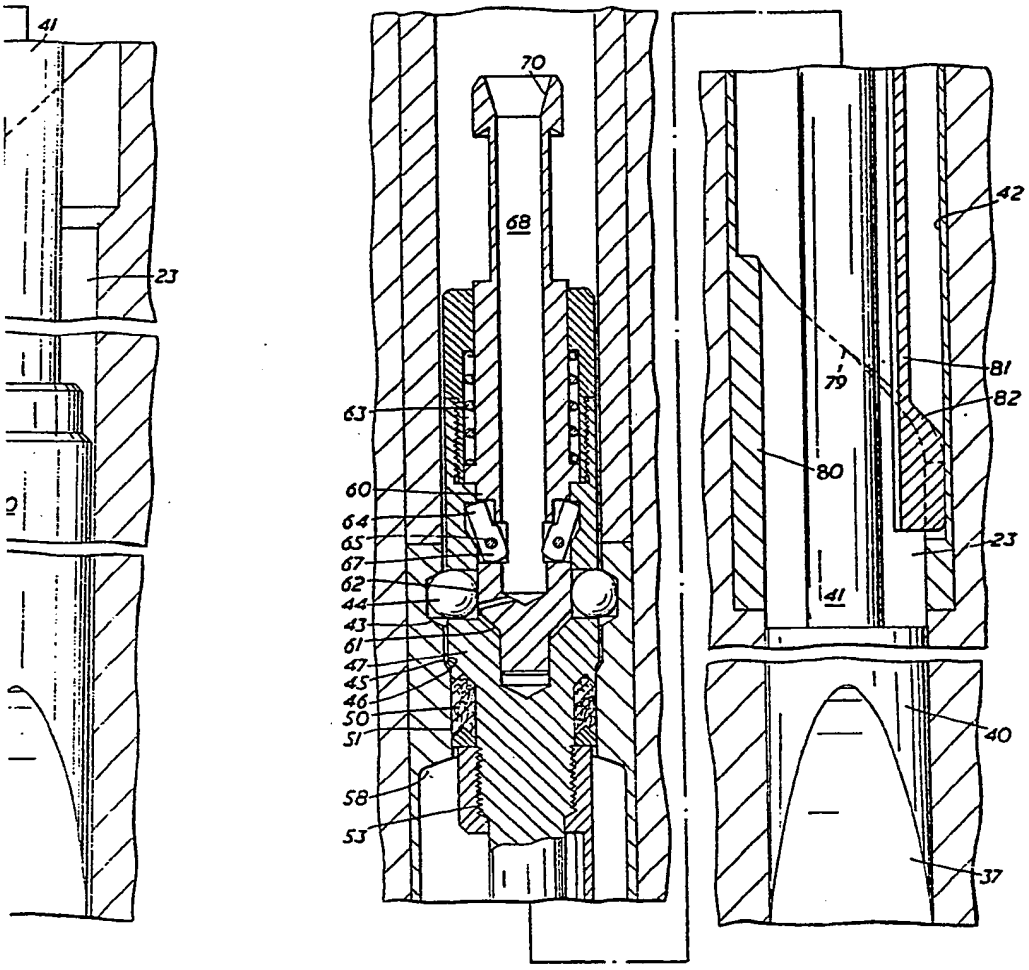

FIG. 3.

956191 COMPLETE SPECIFICATION
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Sheets 2 & 3

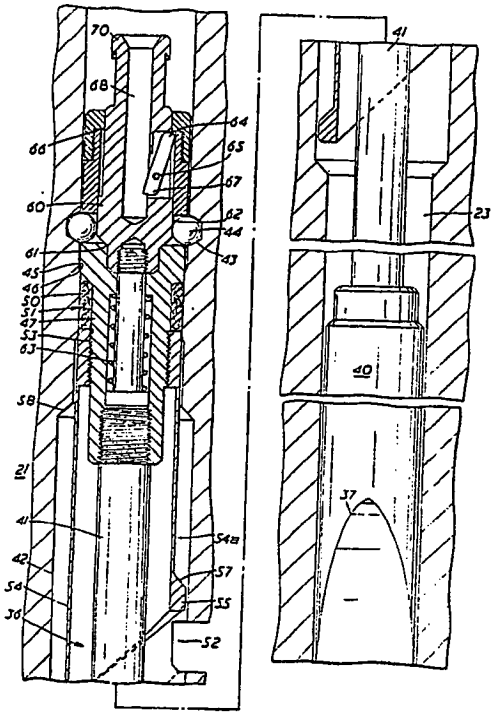

FIG. 2.

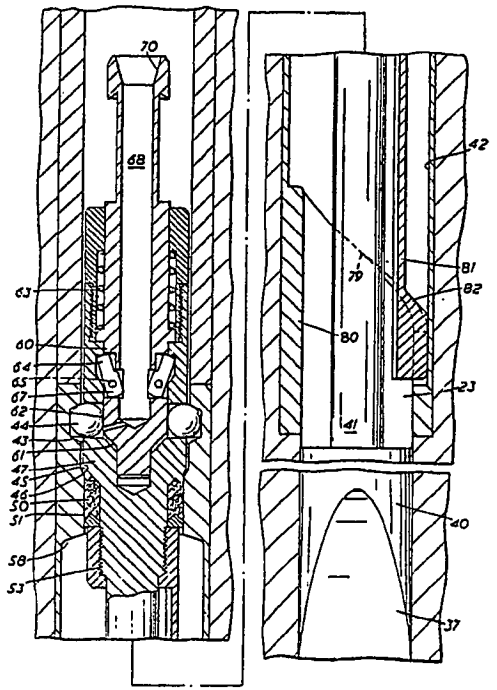

FIG. 3.